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(54) -I(IN VITRO) ASSAY FOR DETECTING CELL-MEDIATED IMMUNE RESPONSES.

BIOLOGICAL ABSTRACTS, vol.73, 1982, Biological Abstracts Inc., Philadelphia, PA (US); R.NETA et al., no. 46873

SCANDINAVIAN JOURNAL OF IMMUNOLOGY, vol.20, 1984; U.ANDERSSON et al., pp.425-432

INFECTION & IMMUNITY, vol.35, no.2, February 1982; R.D.ARBEIT et al., pp.383-390

EUROPEAN JOURNAL OF IMMUNOLOGY, vol.12, no.3, 1982; L.P.SVEDERSKY et al., pp.244-247

JOURNAL OF CLINICAL MICROBIOLOGY, vol.23, no.5, May 1986; "Immune-specific Gamma interferon production correlates with lymphocyte blastogenesis", pp.911-915

Description

This invention relates to the detection of cell-mediated immune responses, and in particular it relates to an in vitro assay method and kit for the detection of such responses.

5   It is well-known that when an antigen enters the body, two different types of immune response may occur. The first type, known as the "humoral immune response", involves the synthesis and release of free antibody into the blood and other body fluids; this antibody acting, for example, by coating bacteria to enhance their phagocytosis and by combination with and neutralisation of bacterial toxins. The second type of immune response, known as the "cell-mediated immune response", involves the production of

10   "sensitized" lymphocytes which are themselves the effectors of this type of immunity. This confers protection against organisms such as the tubercle bacillus and viruses which are characterized by an ability to live and replicate within the cells of the host. In individuals immune to tubercle infection, the "sensitized" lymphocytes interact with injected tuberculin antigen to produce the delayed type hypersensitivity skin response which is the basis of the widely-used "Mantoux" skin test in humans.

15   The present invention relates to the development of a rapid and simple in vitro assay for detecting cell-mediated immune responses in humans and animals. While the invention is particularly described and illustrated herein in relation to the use of the invention in the diagnosis of Mycobacterium bovis infection in cattle it will be understood by persons skilled in the art that the assay system is also applicable for use with other animal species as well as humans, and with a wide range of antigens for the diagnosis of other

20   diseases and syndromes. The present invention also has application in the detection of immunity in individuals, as in testing of humans for immunity to tuberculosis as a preliminary step to ascertain whether or not vaccination is required.

The accurate diagnosis of M.bovis in cattle is an essential part of the bovine tuberculosis (TB) eradication campaign in Australia. The only test currently in use in the detection of TB in cattle is the

25   tuberculin skin test, which suffers from a number of problems:

   1. cattle are required to be held for 3 days to read the test;
   2. the sensitivity of the test is poor under certain conditions, e.g. when cattle are heavily stressed; and
   3. the injection of tuberculin can interfere with subsequent testing by altering the immunological status of the animals.

30   Similar problems arise in the use of this test in the detection of TB in man. There has therefore been a long history of attempts to devise alternative tests for the effective diagnosis of TB both in cattle and man. Serological tests have been found to be less satisfactory than the present tuberculin test because of the low levels of antibody generally found in infected animals and the high frequency of non-specific reactions.

The tuberculin reaction is considered to be a classical example of the delayed type hypersensitivity

35   (DTH) response. Over the past 40 years there have been many attempts to find in vitro equivalents of the DTH response. The earliest assay developed and also the most popular has been the lymphocyte proliferation or blast transformation assay (review, Oppenheim and Schecter, 1980). More recently assays based on the release of soluble mediators (lymphokines) by "sensitized" lymphocytes in response to specific antigen have been developed.

40   All of these in vitro assays have generally required the isolation of lymphocytes from blood, followed by a period of incubation for 2-7 days. The use of whole blood without the requirement for isolation of lymphocytes would provide a simpler, quicker and far more economic assay system.

Scand. J. Immunol. (1984) 20 425-432 describes the measurement of gamma-interferon release in response to Epstein-Barr virus in mononuclear cells (lymphocytes) separated from whole blood. Infect.

45   Immun. (1982) 35 383-390 describes the measurement of gamma-interferon release in response to staphylococcal enterotoxin A in lymphocytes separated from whole blood. European. J. Immunol (1982) 12 244-247 describes the measurement of gamma-interferon release in response to N^α-desacetylthymosin α_1 in lymphocytes separated from whole blood. EP-A-0132754 describes the measurement of gamma-interferon release in response to a leprosy-associated antigen in lymphocytes separated from whole blood.

50   All of these in vitro assays require the isolation of lymphocytes from blood.

Whole blood has been used in lymphocyte proliferation assays (Kaneene et al., 1978; Viljanen and Eskola, 1977; Milner et al, 1981) but several technical problems exist:

   1. the lymphocyte responses in whole blood cultures generally peak later and require longer incubation periods than assays using isolated lymphocytes;

55   2. harvesting of these cultures requires repeated washing steps and decolourizing with acetic acid or hydrogen peroxide; and
   3. the haemoglobin present quenches the signal when counting the amount of tritiated thymidine incorporated into the DNA of lymphocytes.

An alternative method of assaying would be the measurement of the release of lymphokines in a whole blood culture system, and the measurement of the lymphokine, interleukin-2 (IL-2), in whole blood cultures has been used to detect cell-mediated immunity in humans sensitized against Francisella tularensis - (Karttunen et al, 1985).

5   According to the present invention, there is provided an in vitro method of detecting a cell-mediated immune response to a specific antigen in a human or animal, which comprises the steps of:
     1. incubating a whole blood sample from the human or animal with the specific antigen; and
     2. detecting the presence of gamma interferon (γIFN) released by sensitized lymphocytes in said whole blood sample to indicate a cell-mediated immune response to said specific antigen.

10   In another aspect, this invention also provides a diagnostic kit for the detection of a cell-mediated immune response to a specific antigen in a human or animal, comprising:
     a. a source of the specific antigen;
     b. means for incubating said specific antigen with a whole blood sample from the human or animal; and
     c. means for detecting the presence of gamma interferon (γIFN) released by sensitized lymphocytes in
15   the whole blood sample to indicate a cell-mediated immune response to the specific antigen.

     The detection of the presence of γIFN in the whole blood sample may be performed by any suitable means, for example, by a simple bio-assay as described in detail herein, or by means of an immunoassay such as an enzyme-linked immunoassay (ELISA) using monoclonal antibodies specific for γIFN (Le et al, 1984; Tanaka et al, 1985; Van der Meide, 1985). Such detection systems may be simply qualitative, or they
20   may be quantitative of the amount of γIFN produced.

     According to one specific aspect of this invention, the assay method and kit broadly described above provide a simple and rapid method of detecting the specific cell-mediated immune response to the M.bovis antigen, tuberculin purified protein derivative (PPD), in whole blood samples from cattle. The detection of antigen (PPD) specific release of bovine γIFN as a measure of cell-mediated immunity (CMI) has been
25   shown to correlate well with the conventional lymphocyte proliferation assay.

     The development of a simple whole blood γIFN assay for measuring the responsiveness of cattle to bovine PPD makes this test of practical use in the field for diagnosis of M.bovis infections in cattle. In particular, the use of an immunoassay such as ELISA or RIA to quantitate the levels of γIFN produced will provide a simple assay system for use in the field.

30   The advantages of this system over conventional CMI assays is that it does not require the lengthy separation of lymphocytes or the use of complex tissue culture media. This assay also does not compromise the immune status of the animals as does the current in vivo tuberculin skin test. Furthermore, animals are not required to be held for long periods to read the test results.

     In another important aspect, this invention provides a simple and rapid method of testing in vitro for
35   immunity of humans to tuberculosis.

     The accuracy of the current tuberculin in vivo skin test for both epidemiological work and as a diagnostic test for tuberculosis in humans has been frequently questioned (Aziz and Haq, 1985; Burstin et.al., 1986). Other workers have also developed in vitro assays that correlated well with the intensity of delayed skin reactivity to purified protein derivative of tuberculin (PPD) in humans (Oppenheim and
40   Schecter, 1980; Geczy and Meyer, 1982). Immunoassays have also been used to quantitate γIFN production as a measure of cellular responsiveness to M.leprae and Plasmodium falciparum antigens (Kaplan et.al., 1985); Troye-Blomberg et.al. 1985). However all these assays required either the isolation of peripheral blood lymphocytes or lengthy incubation times to obtain satisfactory results, thus making these assays impracticable for general diagnostic purposes.

45   The ability to use undiluted whole blood samples for the production of gamma interferon in the presence of antigen coupled with the use of a simple immunoassay for detecting the amount of γIFN released, as provided by the present invention, has resulted in the development of a cell-mediated response assay that is far simpler and faster than those previously described.

     An additional advantage of an in vitro assay in accordance with this invention over skin testing is that a
50   single blood sample would provide sufficient material for testing a patient's responsiveness to a wide variety of antigens. This would preclude the need for multiple injections and thus avoid the risk of adverse skin reactions e.g vesiculation, ulceration or necrosis may occur at the test site. The injection of antigen into known positive reactors may also result in a febrile reaction or acute hypersensitivity reaction. Multiple skin testing with commonly recognised antigens is used in hospitalised patients to distinguish between antigen
55   specific non-responsiveness and generalised immunosuppression or anergy (Palmer and Reed, 1974; Burstin et.al., 1986).

     As previously described, the assay system of this invention is suitable for use in detecting cellular responses to a wide range of other antigens, e.g. M.leprae, M.tuberculosis, mumps, Candida, Brucella,

histoplasmin, trichophyton, coccidioidin and malaria.

The assay system of the present invention is illustrated by way of example only in the following Examples.

This Example relates to the use of the assay in the diagnosis of M.bovis infection in cattle, and
5 compares this method with the conventional lymphocyte proliferation assay.

EXAMPLE 1

I. Materials & Methods
10

Preparation of peripheral blood lymphocytes (PBL)

Ten to twenty mls of blood is collected into vacutainers containing heparin (20 units/ml) or sodium citrate (3.8%). The blood is then centrifuged at 800g for 20min, the buffy coat removed, diluted up to 10mls
15 with Hanks (GIBCO: Ca^{++}, Mg^{++} free) and overlayed onto 10mls of lymphopaque (BDH: 1.086g/ml). After centrifuging at 800g for 25min the interphase cell layer is collected and washed twice (450g; 10min) with 20mls Hanks. The cells are finally resuspended in 5ml RPMI 1640 (GIBCO) and viable counts done using eosin (0.2%) exclusion.

20 Production of Gamma Interferon (γIFN)

(a) Peripheral blood lymphocytes Isolated lymphocytes are cultured (10^6 cells/ml) in 1ml of RPMI 1640 containing 5% foetal calf serum (FCS), L-glutamine (1mM), 2 mercaptoethanol (2 ME; 5 x 10^{-5}M) and penicillin/streptomycin (100 units/ml). Cells are incubated at 37°C in 5% CO_2 in air for 24–48 hours
25 with antigen (Tuberculin Purified Protein Derivative; PPD) after which their supernatants are harvested and stored at -20°C prior to assay.
(b) Whole blood cultures Blood samples are collected into vacutainers containing heparin (20 units/ml) and antigen (M.bovis PPD 20 μg/ml), and incubated at 37°C for 24 hours. After centrifuging (450g, 10min) the plasma from each tube is removed and stored at -20°C prior to assay.
30

Bio-Assay for Bovine Gamma Interferon (γIFN)

10^4 bovine kidney cells (MDBK: Flow Labs) are added to each well of a 96 well tray (Nunc) and cultured at 37°C in 5% CO_2 in air for 3 days in RPMI medium containing 10% FCS. When the cell
35 monolayers reach confluency, the medium is removed by suction and replaced with 100μl of warm RPMI only. 100μl samples of γIFN supernatants are added to the top wells and serial 2 fold dilutions are prepared down the plate.

After 24 hours the medium is removed and replaced with 100μl of a 1/500 dilution of stock Semliki forest virus (SFV). After a further 48 hours incubation the cells are fixed with 5% formaldehyde and stained
40 with neutral red (0.02%). The γIFN titer is expressed as the reciprocal of the dilution showing 50% cytopathic effect.

Lymphocyte Proliferation Assay Isolated lymphocytes are cultured in flat-bottom 96 well trays (Nunc) at 2.5 x 10^5 cells/well in RPMI containing 5% FCS, L-glutamine, 2ME and antibiotics. After 48 hour incubation with antigen (25μl/well) the cultures are pulsed with tritiated thymidine (Amersham; 0.5 μCi/well) and harvested
45 24 hours later using an automatic cell harvester (Skatron). The amount of tritiated thymidine incorporated is determined using an appropriate scintillant by counting in a liquid β scintillation counter. Results are expressed as mean counts per minute (CPM) of triplicate cultures.

$$\text{Stimulation index (S.I.)} = \frac{\text{mean CPM with antigen}}{\text{mean CPM without antigen}}$$
50

55

Immunization of Cattle

Cattle were immunized by repeated subcutaneous injection of 10mg of killed M.bovis (AN-5 strain) in

1ml of saline. Two cows were infected with live M.bovis (AN-5) by either intravenous injection of 10^4 bacteria or intratracheal injection of 10^7 bacteria.

II RESULTS

The concentrations of M.bovis antigen (PPD) giving optimal stimulation in the lymphocyte proliferation and γIFN assay were similar (Tables 1 and 2). In a control unimmunized cow PPD even at very high concentrations (50-100μg/ml), induced very little activity. In the IFN assay the optimal titer of γIFN detected was present by 24 hours using whole blood whereas with isolated peripheral blood lymphocytes higher levels were detected at 48 hours.

When these assay systems were compared with cells from cattle either immunized with killed M.bovis or infected with live M.bovis there was a good correlation between the results obtained with the two different tests (Tables 3 and 4). Although there were considerable differences in the degree of responsiveness of the different animals all the immunized and infected cattle gave positive responses in the presence of specific antigen.

The cells from M.bovis immunized and infected animals also showed little or no response when incubated in the presence of a similar preparation of antigen (PPD) from Mycobacterium avium, suggesting that these tests are specific for M.bovis.

Table 1

Antigen titration in the Lymphocyte Proliferation Assay				
Antigen Conc (μg/ml)	AN-5 Immunized		Control	
	ΔCPM	S.I.	CPM	S.I.
Nil	0	1.0	0	1.0
1	38,321	15.5	110	1.1
5	53,759	35.4	227	1.2
20	63,457	41.6	1,031	1.8
50	63,543	41.7	1,205	2.0
100	68,026	44.7	1,591	2.3
ΔCPM = mean CPM with antigen - mean CPM without antigen.				

Table 2

Antigen titration in γIFN assay							
		Conc PPD μg/ml					
		Nil	1	5	20	50	100
PBL	24 hr	0	8	16	32	16	64
	48 hr	2	16	31	64	128	128
Whole Blood	24 hr	0	64	64	128	64	64
	48 Hr	0	64	128	128	64	64

Results obtained with whole blood and lymphocytes from an M.bovis immunized cow. When cells or whole blood from an un-immunized cow were used γIFN titer were all <2.

6

Table 3

Lymphocyte Proliferation Assay				
Immunization	Bovine PPD		Avian PPD	
	ΔCPM	S.I.	ΔCPM	S.I.
Nil	843	(1.8)	418	(2.0)
AN-5	47,881	(33.6)	2,681	(2.8)
AN-5	23,973	(35.0)	1,443	(3.0)
AN-5	10,327	(12.3)	323	(1.4)
Live M.bovis	7,843	(5.2)	964	(1.5)
Live M.bovis	40,571	(14.5)	1,263	(1.4)
PPD 20μg/ml.				

Table 4

Release of Gamma Interferon						
Immunization	PBL			Whole Blood		
	Nil	Bovine PPD	Avian PPD	Nil	Bovine PPD	Avian PPD
Nil	0	0	0	0	0	0
AN-5	2	32	4	0	64	0
AN-5	2	8	0	0	4	0
AN-5	0	8	0	0	16	0
Live M.bovis	4	64	4	0	64	8
Live M.bovis	8	64	16	0	256	16
PPD 20 μg/ml.						

EXAMPLE 2

The whole blood IFN assay of this invention as described in Example 1 above was also tested under field conditions for its ability to detect M.bovis infected cattle.

Heparinized blood samples were collected from cattle in various herds just prior to tuberculin skin testing these animals. One ml whole blood samples were cultured in the presence of either M.bovis PPD, M.avium PPD or no antigen and the supernatants collected 24 hours later and assayed for IFN activity.

In herds 1 and 2 the IFN assay of this invention detected 2 M.bovis infected animals (Table 5) whereas the skin test detected only one of these animals. The IFN assay was also able to correctly diagnose 4 false positive tuberculin reactors found in herds 3, 4, 5 and 7. It is interesting to note that the four Johnes disease (Mycobacterium paratuberculosis) infected animals detected by strong IFN responses to avium/johnin antigen compared to bovis PPD were all sub-clinical cases. Therefore, with the use of an appropriate antigen, the assay of this invention will also be useful for diagnosis of Johnes disease infected cattle.

The test results obtained with the assay of this invention also correlated well with skin testing when used to detect tuberculosis infected water buffalo (Table 6). Six infected animals were positive in both the IFN assay and the skin test and one animal (No.3) gave a false positive reaction in the skin test. This animal also showed the same degree of IFN activity in both the presence and absence of added antigen which could be due to alpha or beta interferons in the blood sample. The bioassay which was used to detect IFN in this test does not distinguish between the different species of interferons (alpha, beta and gamma). For this reason a positive response in the IFN assay was only recorded when there was an increase in IFN production in the presence of antigen compared to no antigen.

Overall the γIFN test results compared well with the skin test for the diagnosis of tuberculosis. The problem with the presence of other species of interferon in samples from some animals can be resolved by using a monoclonal based immunoassay to quantify the amount of γIFN produced rather than the bioassay

used in Examples 1 and 2.

TABLE 5:

Field trial of IFN assay for the diagnosis
of bovine tuberculosis

Herd	Size of Herd	#Interferon Titre			Skin Test Result	Final Diagnosis
		Nil	Avium/Johnin	Bovis		
1	90	0	4	64	+	T
2	38	0	0	256	–	T
3	NA	0	0	0	+	NVL
4	NA	0	32	8	±	J
5	NA	0	32	0	±	J
6	158	2	32	4	–	J
7	156	0	16	2	+	J
8	4	0	8	8	+	ST

\#   The interferon results represent the individual
    titres of one animal from each of the herds
    listed. All other animals in these herds were
    negative in the interferon and skin tests.

NA   = not available.
NVL   = no visible lesions.
T   = Tuberculosis
J   = Johnes
ST   = Skin Tuberculosis

8

TABLE 6

Interferon assay trial in a water buffalo herd.				
Animal Number	Interferon Titre			Skin Test Result	Final Diagnosis
	Nil	Avium	Bovis		
1	0	0	16	+	T
2	0	0	64	+	T
3	4	4	4	+	NVL
4	0	0	64	+	T
5	0	0	8	ND	T
6	0	0	128	+	T
7	0	0	16	+	T
8	2	4	64	+	T

NVL = no visible lesions

ND = not done

T = Tuberculosis

EXAMPLE 3

A trial was established to examine the suitability of the whole blood γIFN assay according to this invention for detection of cellular responses to defined antigens in humans.

Heparinized blood samples were collected from medical students prior to skin testing (Mantoux testing) these individuals. One ml whole blood samples were incubated at 37°C with M.bovis (PPD 100μg/ml) or no added antigen. After 24 hours the supernatants were collected and assayed for γIFN using a monoclonal antibody based radio-immunoassay (Centocor, Pennsylvania). The amount of γIFN present was recorded as counts per minute and converted to γIFN units/ml by comparison with a standard curve constructed by plotting the γIFN concentration of three known standards versus bound radioactivity. The skin test results were read 72 hours after injection of antigen (10 i.u. PPD; CSL) and recorded as the diameter of the erythema produced. Table 7 shows the skin test result and interferon titres from 34 students.

If a positive response to antigen (PPD) in the interferon assay was recorded for any individual that had an increase of greater than 3 units/ml γIFN in the presence of antigen compared to no antigen, only two results (students 4 and 7) would be at variance with the skin test data. Most of the students were positive in both the skin test and interferon assay, which was expected as the majority of them had been vaccinated against tuberculosis with BCG. Only two individuals (No.1 and 2) could not recall any previous history of BCG vaccination and both of these students gave negative responses in both assays. A linear regression analysis of this data transformed to log values showed that there was a significant correlation between the two test results (R-square = 0.59, P < 0.001). Therefore the interferon assay could readily be substituted for the Mantoux test as an assay of cellular reactivity to PPD.

Table 7

Gamma Interferon titres and Mantoux skin test diameters for 34 students			
PATIENT	INTERFERON TITRE (UNITS/ML)		SKIN TEST DIAMETER (mm)
	NO ANTIGEN	PPD	
1	0.1	0.6	0
2	0.8	1.0	0
3	0.2	3.6	9
4	0.4	4.0	0
5	0.6	4.0	12
6	0.1	4.2	9
7	ND	6.0	0
8	0.1	7.0	5
9	0.1	7.6	10
10	0.2	8.0	9
11	0.4	9.0	15
12	0.6	9.0	17
13	0.2	9.2	10
14	0.2	10.0	12
15	0.2	10.2	15
16	0.2	12.0	12
17	0.1	12.4	15
18	0.1	12.6	10
19	0.1	13.4	9
20	1.0	14.6	9
21	0.2	15.0	15
22	2.0	16.0	25
23	0.6	17.2	20
24	0.1	17.4	10
25	0.2	17.6	10
26	0.7	20.0	20
27	1.8	21.0	12
28	0.5	21.6	25
29	0.2	24.0	12
30	0.1	24.4	15
31	0.1	26.4	20
32	0.1	27.8	15
33	0.1	34.6	22
34	0.6	36.0	16
ND = Not done			

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Claims

1. An in vitro method of detecting a cell-mediated immune response to a specific antigen in a human or animal, which comprises the steps of:
   (i) incubating a whole blood sample from the human or animal with the specific antigen; and
   (ii) detecting the presence of gamma interferon (γIFN) released by sensitized lymphocytes in said whole blood sample to indicate a cell-mediated immune response to said specific antigen.

2. A method according to claim 1, wherein said step of detecting the presence of gamma interferon is an immunoassay for gamma interferon.

3. A method according to claim 2, wherein said immunoassay is an enzyme-linked immunosorbent assay (ELISA) or a radio-immunoassay (RIA) for gamma interferon.

4. A method according to any one of claims 1 to 3, wherein said specific antigen is an antigen of Mycobacterium bovis, Mycobacterium paratuberculosis, or Mycobacterium tuberculosis, or an antigen immunologically cross-reactive therewith.

5. A method according to claim 1, for the detection of M.bovis infections in cattle and similar bovines, wherein said specific antigen is the M.bovis antigen, tuberculin purified protein derivative (PPD).

6. A diagnostic kit suitable for use in a method according to claim 1 for the detection of a cell-mediated immune response to a specific antigen in a human or animal, comprising:
   a. a source of the specific antigen;
   b. means for incubating said specific antigen with a whole blood sample from a human or animal; and
   c. means for detecting the presence of gamma interferon (γIFN) released by sensitized lymphocytes in the whole blood sample to indicate a cell-mediated immune response to the specific antigen.

7. A kit according to claim 6, wherein said means for detecting the presence of gamma interferon comprises means for performing an immunoassay for gamma interferon.

8. A kit according to claim 7, wherein said immunoassay means comprises an enzyme-linked immunosorbent assay (ELISA) or a radio-immunoassay (RIA) for gamma interferon.

9. A kit according to any one of claims 6 to 8, wherein said specific antigen is an antigen of

Mycobacterium bovis, Mycobacterium paratuberculosis, or Mycobacterium tuberculosis, or an antigen immunologically cross-reactive therewith.

10. A kit according to claim 6, for the detection of M.bovis infections in cattle and similar bovines, wherein said specific antigen is the M.bovis antigen, tuberculin purified protein derivative (PPD).

Revendications

1. Procédé de détection in vitro d'une réponse immune à médiation cellulaire, dirigée contre un antigène spécifique chez l'homme ou l'animal, selon lequel :

(i) on incube un échantillon de sang entier provenant de l'homme ou de l'animal comportant l'antigène spécifique ; et

(ii) on détecte la présence d'interféron gamma (IFN-γ) libéré par des lymphocytes sensibilisés dans l'échantillon de sang entier, afin de révéler une réponse immune à médiation cellulaire dirigée contre l'antigène spécifique.

2. Procédé selon la revendication 1, dans lequel l'opération de détection de la présence d'interféron gamma, consiste en une analyse immunologique de l'interféron gamma.

3. Procédé selon la revendication 2, dans lequel l'analyse immunologique consiste en un essai par immunosorbant lié à une enzyme (ELISA) ou en un essai radioimmunologique (RIA) de l'interféron gamma.

4. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel l'antigène spécifique est un antigène de Mycobacterium bovis, de Mycobacterium paratuberculosis ou de Mycobacterium tuberculosis, ou un antigène donnant lieu à une réaction immunologique croisée avec celui-ci.

5. Procédé selon la revendication 1, pour la détection d'infections par M. bovis chez les bovins et les bovinés analogues, l'antigène spécifique étant l'antigène de M. bovis consistant en un dérivé protéique purifié (PPD) de la tuberculine.

6. Nécessaire de diagnostic adapté à un emploi selon le procédé de la revendication 1, pour la détection d'une réponse immune à médiation cellulaire dirigée contre un antigène spécifique chez l'homme ou l'animal, comprenant :

a) une source de l'antigène spécifique ;

b) des moyens d'incubation de cet antigène spécifique, avec un échantillon de sang entier provenant d'un homme ou d'un animal ; et

c) des moyens de détection de la présence d'interféron gamma (IFN-γ) libéré par des lymphocytes sensibilités dans l'échantillon de sang entier, afin de révéler une réponse immune à médiation cellulaire, dirigée contre l'antigène spécifique.

7. Nécessaire selon la revendication 6, dans lequel les moyens de détection de la présence d'interféron gamma, comprennent des moyennes d'analyse immunologique de l'interféron gamma.

8. Nécessaire selon la revendication 7, dans lequel l'analyse immunologique comprend un essai par immunosorbant lié à une enzyme (ELISA) ou un essai radioimmunologique (RIA) de l'interféron gamma.

9. Nécessaire selon l'une quelconque des revendications 6 à 8, dans lequel l'antigène spécifique est un antigène de Mycobacterium bovis, de Mycobacterium paratuberculosis ou de Mycrobacterium tuberculosis, ou un antigène donnant lieu à une réaction croisée avec celui-ci.

10. Nécessaire selon la revendication 6, pour la détection d'infections par M. bovis chez les bovins et les bovinés analogues, l'antigène spécifique étant l'antigène de M. bovis consistant en un dérivé protéique purifié (PPD) de la tuberculine.

Patentansprüche

1. In-vitro-Verfahren zum Nachweis einer zellvermittelten Immunantwort auf ein spezifisches Antigen bei

Mensch oder Tier, umfassend folgende Stufen:

(1) Inkubieren einer Vollblutprobe von Mensch oder Tier mit dem spezifischen Antigen und

(2) Nachweis der Anwesenheit von durch sensibilisierte Lymphozyten in der Vollblutprobe freigesetztem γ-Interferon (γIFN) als Hinweis auf eine zellvermittelte Immunantwort auf das spezifische Antigen.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der Nachweis der Anwesenheit von γ-Interferon im Rahmen eines Immuntests auf γ-Interferon erfolgt.

3. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß es sich bei dem Immuntest um einen enzym-verknüpften Immun(ad)sorptionstest (ELISA) oder einen Radioimmuntest (RIA) für γ-Interferon handelt.

4. Verfahren nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß es sich bei dem spezifischen Antigen um ein Antigen von Mycobacterium bovis, Mycobacterium paratuberculosis oder Mycobacterium tuberculosis oder ein damit eine immunologische Kreuzreaktion eingehendes Antigen handelt.

5. Verfahren nach Anspruch 1 zum Nachweis von M. bovis-Infektionen bei Rindern und ähnlichen rinderartigen Tieren, wobei das spezifische Antigen das M. bovis-Antigen, gereinigtes Tuberculin-Proteinderivat (PPD) ist.

6. Zur Verwendung im Rahmen eines Verfahrens gemäß Anspruch 1 zum Nachweis einer zellvermittelten Immunantwort auf ein spezifisches Antigen bei Mensch oder Tier geeignetes Diagnosebesteck, umfassend:

a) eine Quelle für das spezifische Antigen;

b) Mittel zum Inkubieren des spezifischen Antigens mit einer Vollblutprobe von Mensch oder Tier und

c) Mittel zum Nachweis der Anwesenheit von durch sensibilisierte Lymphozyten in der Vollblutprobe freigesetztem γ-Interferon (γIFN) als Hinweis auf eine zellvermittelte Immunantwort auf das spezifische Antigen.

7. Besteck nach Anspruch 6, dadurch gekennzeichnet, daß die Mittel zum Nachweis der Anwesenheit von γ-Interferon aus Mitteln zur Durchführung eines Immuntests auf γ-Interferon bestehen.

8. Besteck nach Anspruch 7, dadurch gekennzeichnet, daß die Immuntestmittel einem enzym-verknüpften Immun(ad)sorptionstest (ELISA) oder einem Radioimmuntest (RIA) auf γ-Interferon dienen.

9. Besteck nach einem der Ansprüche 6 bis 8, dadurch gekennzeichnet, daß es sich bei dem spezifischen Antigen um ein Antigen von Mycobacterium bovis, Mycobacterium paratuberculosis oder Mycobacterium tuberculosis oder ein damit eine immunologische Kreuzreaktion eingehendes Antigen handelt.

10. Besteck nach Anspruch 6 zum Nachweis von M. bovis-Infektionen bei Rindern und ähnlichen rinderartigen Tieren, wobei das spezifische Antigen das M. bovis-Antigen, gereinigtes Tuberculin-Proteinderivat (PPD) ist.